# Double Emergence, One Fluid: A Consolidated Formalism, Cross-Domain Link, and Falsifiability

(DES Master Addendum v1.2)

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**Abstract**

This master addendum consolidates the Double Emergence Suppression (DES) into a single, self-contained document that (i) formalizes the two-stage emergence from quantum substrate to spacetime and from spacetime to effective gravity, (ii) defines a one-fluid cosmology (DES-fluid) that replaces ΛCDM at the level of growth while preserving benchmark background distances when desired, (iii) specifies a minimal EFT benchmark on the collider side (top-philic, lepton-cloud scalar) that is tied to the same DES parameter set, and (iv) states *pre-registered, binary falsification criteria*. Provenance and supplemental materials are provided via Zenodo records: DES core ontology [1], DES-fluid [2], DES-Layers [3], Anomaly Map and pre-registered predictions [4], DES-SM/EFT benchmark card [5], and the minimal Crosslink note [6].

## 1 Provenance and Scope

This document is the canonical consolidation of prior DES materials. It should be cited as the entry point for the DES ontology, the DES-fluid cosmology, the DES-SM/EFT link, and the falsification program. The detailed records remain available as versioned supplements on Zenodo [1, 2, 3, 4, 5, 6].

## 2 micro-meso-macro: Structure at a Glance

DES posits two coarse-graining stages that suppress entanglement and information flow, resulting in weak effective gravity and a *single* dark-sector fluid at cosmological scales. Figure 1 schematically shows the flow; Figure 2 shows how one parameter set controls both cosmological growth and collider signatures.

## 3 Formalism

### 3.1 Two-Stage Coarse Graining and Entanglement Contraction

Let $\mathsf{D}(\mathcal{H}_{\mathrm{QM}})$, $\mathsf{D}(\mathcal{H}_{\mathrm{ST}})$, and $\mathsf{D}(\mathcal{H}_{\mathrm{GR}})$ denote density operators over the effective micro, meso, and macro Hilbert spaces. Consider two completely positive, trace-preserving (CPTP) maps

$$\mathcal{M}_1 : \mathsf{D}(\mathcal{H}_{\mathrm{QM}}) \to \mathsf{D}(\mathcal{H}_{\mathrm{ST}}), \qquad \mathcal{M}_2 : \mathsf{D}(\mathcal{H}_{\mathrm{ST}}) \to \mathsf{D}(\mathcal{H}_{\mathrm{GR}}). \tag{1}$$

For an entanglement monotone $\mathsf{E}$ (e.g. a relative-entropy based functional), DES imposes

$$\mathsf{E}\big[(\mathcal{M}_2 \circ \mathcal{M}_1)(\rho)\big] \;\le\; \epsilon_1\,\epsilon_2\,\mathsf{E}(\rho), \qquad 0 < \epsilon_i \ll 1, \tag{2}$$

so that the overall contraction factor $\epsilon = \epsilon_1\epsilon_2 \ll 1$ quantifies the double-emergent suppression of correlations transported to the gravitational level.

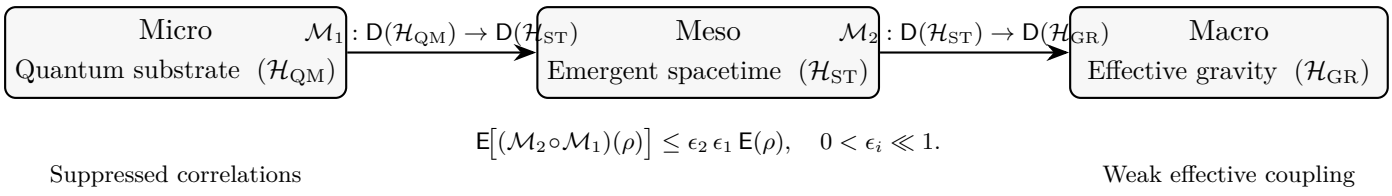


Figure 1: DES layers and contraction of entanglement monotones under two-stage coarse graining.

### 3.2 Local Equilibrium and Effective Field Equations

Assuming local modular/KMS equilibrium patches on $\mathcal{H}_{\mathrm{ST}}$ and propagation through (2), the emergent gravitational sector admits an effective field equation of the form

$$G_{\mu\nu} + \Lambda\, g_{\mu\nu} \;=\; 8\pi\, G_{\mathrm{eff}}\, T_{\mu\nu} \;+\; \Delta_{\mu\nu}^{(\mu,\Sigma)}, \tag{3}$$

where $G_{\mathrm{eff}} = \epsilon^{\alpha}\, G_{\star}$ with $\alpha > 0$ and $G_{\star}$ a substrate scale, and $\Delta_{\mu\nu}^{(\mu,\Sigma)}$ encodes *small*, scale-dependent response consistent with weak-modified-gravity parametrizations $(\mu, \Sigma)$ defined below. In homogeneous backgrounds, $G_{\mathrm{eff}}$ renormalizes the coupling without spoiling the equivalence principle at leading order.

### 3.3 DES-Fluid: One-Fluid Cosmology

The dark sector is treated as a single fluid with a smooth equation-of-state family

$$w_U(a) \;=\; -1 \;+\; \frac{1}{1 + (a/a_t)^m}, \qquad m > 0,\; a_t \in (0, 1], \tag{4}$$

and a small rest-frame sound speed on linear scales,

$$c_s^2 \ll 1 \quad \text{for} \quad k \lesssim 0.2\, h\,\mathrm{Mpc}^{-1}. \tag{5}$$

Background distances may be *benchmarked* to ΛCDM ($E_{\mathrm{DES}}(z) = E_{\Lambda\mathrm{CDM}}(z)$) for clean growth tests; deviations are carried by the linear growth sector through

$$D'' + \Big(2 + \frac{H'}{H}\Big) D' \;-\; \frac{3}{2}\,\Omega_m(a)\,\mu(a,k)\,D \;=\; 0, \tag{6}$$

with weak modifiers

$$\mu(a,k) = 1 - \delta_\mu(a,k), \qquad \Sigma(a,k) = 1 + \delta_\Sigma(a,k), \qquad |\delta_{\mu,\Sigma}| \lesssim 0.01\text{–}0.02, \tag{7}$$

implying a mild suppression of $S_8$ without disturbing benchmark distances. An optional early-DES phase can reduce the sound horizon by a few percent, $\Delta r_s / r_s \sim -2\%$ to $-4\%$, providing a conservative lever on $H_0$ while retaining the one-fluid ontology.

### 3.4 Minimal DES-SM/EFT Benchmark (Collider Side)

On the particle side, we adopt a minimal, top-philic, lepton-cloud scalar EFT: a scalar $\phi$ with effective gluon coupling, mass in the range

$$m_\phi \in [340, 350]\ \mathrm{GeV}, \qquad \Gamma_\phi \sim 3\text{–}10\ \mathrm{GeV},$$

interfering with QCD near the $t\bar{t}$ threshold. This yields a *shoulder*-like deformation rather than a narrow bump in $m_{t\bar{t}}$, and is correlated—via the same DES parameter set—with percent-level CPV in selected heavy-baryon channels (LHCb). Dilepton and dijet remain *null* channels in this window; four-top is only mildly enhanced. The implementation details and UFO card are provided in the DES-SM/EFT supplement [5], with data organization and pre-registered channels in [4].

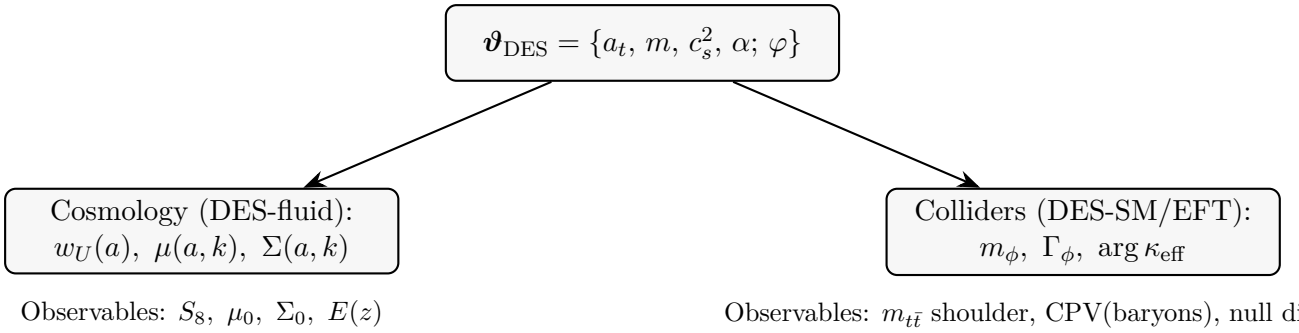


Figure 2: Crosslink: one parameter set, two domains. Benchmarked distances isolate growth; collider side uses a minimal top-philic EFT.

## 4 Crosslink: One Parameter Set for Cosmos and Colliders

Let $\boldsymbol{\vartheta}_{\rm DES}$ denote the compact DES parameter set (e.g. transition scale $a_t$, steepness $m$, linear-scale $c_s^2$, an overall suppression exponent $\alpha$ feeding $G_{\rm eff}$, and a CPV phase $\varphi$ entering the EFT). The cross-domain mapping is

$$\boldsymbol{\vartheta}_{\rm DES} \;\longmapsto\; \Big\{\mu(a,k),\, \Sigma(a,k),\, w_U(a)\Big\} \;\oplus\; \Big\{m_\phi,\, \Gamma_\phi,\, \arg\kappa_{\rm eff}(\varphi)\Big\}. \tag{8}$$

A *single* choice of $\boldsymbol{\vartheta}_{\rm DES}$ must simultaneously fit linear growth (mild $\mu < 1$ and $\Sigma \gtrsim 1$ within the DES bands) *and* the collider observables (threshold shoulder and CPV). This is the operational content of the Crosslink [6].

## 5 Pre-Registered Predictions and Binary Falsification

*Editorial note.* The falsifiers stated in this section are the definitive DES criteria *for each sector*. They are not to be broadened, softened, or reinterpreted in later versions. DES-fluid (cosmology) and DES-SM/EFT (colliders) are independently falsifiable. The crosslinked DES claim requires the same parameter set to satisfy both sectors; failure of the crosslink does not negate a confirmed sector result. The sharpness of these windows is deliberate.

This section states the *numerical* targets and the associated binary rules. Data organization and channels are catalogued in the Anomaly Map [4].

### Cosmology (Linear Scales)

- **Amplitude of fluctuations:**

$$S_8 \;=\; 0.75 \pm 0.02 \quad \text{(linear scales, } k \lesssim 0.2\,h\,\text{Mpc}^{-1}\text{)}.$$

  *Falsification:* If $S_8 > 0.82$ at $\geq 2\sigma$ on linear scales, DES is rejected.

- **Weak MG response:**

$$\mu_0 \in [0.98, 1.00], \qquad \Sigma_0 \in [1.00, 1.02].$$

  *Falsification:* If $|\mu_0 - 1| > 0.02$ *or* $|\Sigma_0 - 1| > 0.02$ at $\geq 2\sigma$ (linear scales), DES is rejected.

- **One-fluid ontology:** Background and growth must be fit with a *single* fluid. *Falsification:* If two independent dark components are *required* to fit both background and growth, the DES-fluid ontology is rejected.

- **Optional early-DES lever:** If used, target $\Delta r_s/r_s = -2\%$ to $-4\%$. *Falsification:* If data require $|\Delta r_s| > 5\%$ or the opposite sign to resolve tensions, the option is rejected.

### Colliders (Run 3 focus)

- $t\bar{t}$ **threshold morphology:** A non-narrow *shoulder* with effective step width

$$\Gamma_{\rm step}^{\rm eff} \gtrsim 3\,{\rm GeV} \quad \text{for} \quad m_\phi \in [340, 350]\ {\rm GeV}.$$

  *Falsification:* If high-statistics data prefer $\Gamma_{\rm step}^{\rm eff} < 2\,{\rm GeV}$ and no shoulder, DES-SM is rejected.

- **Heavy-baryon CPV (LHCb):** Persistent percent-level CPV in pre-registered channels, with new-target band

$$\mathcal{A}_{CP} \sim 0.2\%\text{–}0.6\%.$$

  *Falsification:* If $\mathcal{A}_{CP} < 0.1\%$ at $\geq 3\sigma$ in the stated channels, DES-SM is rejected.

- **Null channels:** No narrow resonant bump in dilepton/dijet around 340–350 GeV; four-top only mildly enhanced. *Falsification:* Observation of a *narrow* dilepton/dijet resonance in that window rejects DES-SM.

### Tabular Summary

| Domain | Target (Prediction) | Binary falsification rule |
|---|---|---|
| Cosmo | $S_8 = 0.75 \pm 0.02$ | $S_8 > 0.82$ @ $2\sigma$ (linear) $\Rightarrow$ reject DES |
| Cosmo | $\mu_0 \in [0.98, 1.00]$ | $\lvert\mu_0 - 1\rvert > 0.02$ @ $2\sigma$ (linear) $\Rightarrow$ reject |
| Cosmo | $\Sigma_0 \in [1.00, 1.02]$ | $\lvert\Sigma_0 - 1\rvert > 0.02$ @ $2\sigma$ (linear) $\Rightarrow$ reject |
| Cosmo | one-fluid fit | need two dark components $\Rightarrow$ reject DES-fluid |
| Cosmo (opt.) | $\Delta r_s/r_s = -2\% \ldots -4\%$ | $\lvert\Delta r_s\rvert > 5\%$ or wrong sign $\Rightarrow$ reject option |
| Collider | $t\bar{t}$ shoulder, $\Gamma_{\rm step}^{\rm eff} \gtrsim 3\,{\rm GeV}$ | $< 2\,{\rm GeV}$ and no shoulder $\Rightarrow$ reject DES-SM |
| Collider | CPV $0.2\% \ldots 0.6\%$ | $< 0.1\%$ @ $3\sigma$ in channels $\Rightarrow$ reject DES-SM |
| Collider | no narrow dilepton/dijet bump | narrow bump at 340–350 GeV $\Rightarrow$ reject DES-SM |

**Scope of claims (clarification).** This manuscript makes three nested claims: (i) **DES-fluid (cosmology-only)** is an independently falsifiable replacement for ΛCDM at the level of growth, governed by the cosmological falsifiers listed above; (ii) **DES-SM/EFT (collider-only)** is an independently falsifiable benchmark against the Standard Model, governed by the collider falsifiers listed above; (iii) **Crosslinked DES (full theory)** requires a single parameter set to satisfy both sectors simultaneously. A failure of (iii) does not retroactively negate a success at (i) or (ii); it only rules out the crosslink. *All numerical falsifiers remain unchanged and definitive.*

## 6 Implementation Notes and Versioning

**Cosmology:** Implement $(w_U(a), c_s^2)$ and $(\mu, \Sigma)$ in a Boltzmann+MCMC pipeline. Use a background benchmark equal to ΛCDM to isolate growth. Report posteriors for $(S_8, \mu_0, \Sigma_0)$ with clear linear-scale cuts (e.g. $k \lesssim 0.2\,h\,{\rm Mpc}^{-1}$).
**Colliders:** Use the DES-SM/EFT UFO card [5] to generate $m_{t\bar{t}}$ spectra and CPV reaches; log channels and thresholds in the Anomaly Map [4].
**Versioning:** This is the master record. Future updates should appear as v1.1, v2.0, etc., while prior Zenodo entries remain as *supplements*.

# 7 Conclusions

DES provides a compact ontology in which gravity is weak because correlations are doubly suppressed under micro→meso→macro coarse graining, and the dark sector reduces to a single fluid whose distinctive imprint is a small, controlled deviation in linear growth. The same few parameters drive a minimal collider EFT producing a $t\bar{t}$ shoulder and percent-level baryon CPV while preserving null dilepton/dijet signatures. The predictions above are intentionally binary: if nature refuses them, DES should be set aside.


## Acknowledgments

The DES framework and materials cited here are authored and maintained by Christian Sommerseth. The consolidation and formalization in this master addendum integrate the prior public Zenodo records into a single, citable document.


## References


[1] C. Sommerseth, *The Double-Emergence Framework: Unifying Quantum Mechanics and Gravity (DES v1.0)*, Zenodo (2025). DOI:10.5281/zenodo.16794557.

[2] C. Sommerseth, *DES-fluid: Standalone Ontology and Cosmological Replacement for $\Lambda CDM$*, Zenodo (2025). DOI:10.5281/zenodo.16913640.

[3] C. Sommerseth, *DES-Layers: Micro–Meso–Macro Interfaces and Emergent Paradox Resolution*, Zenodo (2025). DOI:10.5281/zenodo.16925596.

[4] C. Sommerseth, *DES/DES-fluid Anomaly Map and Pre-Registered Predictions: Alignment of LHC Run 1–3 Data with DES*, Zenodo (2025). DOI:10.5281/zenodo.16927154.

[5] C. Sommerseth, *DES-SM/EFT Benchmark: Top-Philic Lepton-Cloud Scalar (UFO card and notes)*, Zenodo (2025). DOI:10.5281/zenodo.16891590.

[6] C. Sommerseth, *DES Crosslink v1.0: Minimal Cosmology↔Collider Lock*, Zenodo (2025). DOI:10.5281/zenodo.16936055.